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Recalibration of the multisensory temporal window of integration

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Abstract

Information about on-going events in the environment typically arrives in parallel via different sensory channels. In order to achieve a coherent and valid perception of the outside world, the brain must determine which of these temporally coincident sensory signals are caused by the same physical source and thus should be integrated into a single percept (Körding et al., 2007). This task is made more difficult by the fact that there are subtle differences in arrival times, for example, of sound and light: For a synchronized audiovisual event occurring in the near field, audition will be perceived before vision by about 30 ms because neural transduction for audition is much faster than for vision. This more than compensates for the slower physical speed of sound. Nevertheless, in daily life we are typically not aware of these subtle differences in arrival time of sound and light and most often perceive the stimuli as simultaneous. The range of arrival time differences the brain tolerates in treating the two information streams as belonging to the same event has been termed *temporal window of integration* (TWI; Vroomen & Keetels, 2010). The exact size of this window, its potential malleability, and dependence on stimulus properties and individual differences have been the focus of many studies in multisensory research.

Primarily two experimental approaches have been used to probe the TWI concept. The first one measures reaction time (RT) as an index of multisensory integration. The second asks participants to report which stimulus they perceived first (temporal order judgment, TOJ); sometimes, judgment of simultaneity (SJ) is elicited, either in addition or instead of TOJ. In a recent study, Mégevand et al. (2013) found that the size of the TWI is affected by the demands of the experimental task used to measure it. In a redundant signals RT task, participants were asked to respond as quickly as possible to the stimulus detected first, whether visual or auditory. In the TOJ task, the observer was asked to report which stimulus had the earlier onset. Their operational definition of TWI in this study differed for the two tasks, however:

(1) Data from the RT task was tested for violations of the race model inequality (Miller, 1986). This "classic" model assumes that the response in the bimodal condition is determined by the "winner of a race" between the sensory-specific channels. For each stimulus onset asynchrony (SOA), the inequality compares the distribution function of RTs in the bimodal condition with the sum of the two unimodal distribution functions. If certain assumptions are met, a violation of the inequality indicates that the speed-up

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of RTs in the bimodal condition is greater than predicted by a simple probability summation model. Using a conservative test method, all but one participant showed a significant violation of the inequality at SOA = 0 ($p<.05$), and none of them displayed a violation beyond the ±120 SOA range. Violations were more common with the visual stimulus leading the auditory one. Separately for each participant, TWI(RT) was defined by the contiguous SOAs with significant violations of the RMI that were around physical simultaneity or closest to it. This definition of TWI(RT) is based on the idea that violations of the RMI at a specific SOA value are due to both unisensory processes falling into a temporal window so that multisensory integration speeds up bimodal responses beyond what can be achieved by statistical facilitation alone.

(2) For the TOJ task, audiovisual stimulus pairs were presented with the same set of SOAs as for the RT task. Logistic psychometric functions were fitted to participants' proportion of “visual first” responses across SOA in a Bayesian analysis (using a Markov chain Monte Carlo algorithm for estimation of the posterior distribution of the parameters). Above-chance performance in the TOJ task was defined by the upper and lower time points on the SOA axis where performance was at the 75% correct level (with a correction in case of lapses) yielding a TWI(TOJ) defined as the corresponding range on the proportion of “visual first” responses. This definition of TWI is based on the idea that highly accurate discrimination of visual and auditory arrival times is only possible outside of that window.

TWI in the RT task turned out to be wider than in a corresponding TOJ task. This was consistent with the authors' hypothesis, namely, that in the latter task where participants have to discern small asynchronies between the auditory and the visual stimulus, the TWI is set to a value as narrow as possible for optimal performance. Optimal performance in the RT task, however, would entail widening the window to maximize multisensory facilitation (ibid., p. 2). Given that their operational definition of TWI in this study differed for the two tasks, there is a possibility that observing different TWIs in the two tasks was due to this circumstance alone.

An alternative approach presented here is based on a quantitative model framework for multisensory integration (time window of integration, TWIN, model) (Colonius & Diederich, 2004; Diederich & Colonius, 2004). Width of the TWI is treated as a numerical model parameter modulating RT speed. Because the TWIN model specifies the probability of integration as well, it predicts performance in both the TOJ and RT task as a function of SOA. A version of that model framework was fitted separately for the eleven subjects of Mégevand et al. (2013) such that the window width parameter was allowed to differ for the TOJ and RT data. For all subjects, the TWI parameter turned out to be smaller for TOJ than for RT consistent with the hypothesis of Mégevand and colleagues, and this result was supported by statistical evaluation.

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Keywords: Multisensory integration; Time window; Temporal order judgment; Reaction time; TWIN model

References

Colonius, H., & Diederich, A. (2004). Multisensory interaction in saccadic reaction time: a time-window-of-integration model. *Journal of Cognitive Neuroscience*, *16*, 1000-1009.

Diederich, A., & Colonius, H. (2004). Modeling the time course of multisensory interaction in manual and saccadic responses. In: G. Calvert, C. Spence, & B. E. Stein BE (Eds.), *Handbook of multisensory processes* (pp. 395-408). Cambridge, MA: MIT Press.

Körding, K. P., Beierholm, U., Ma, W. J., Quartz, S., Tenenbaum, J. B., et al. (2007) Causal inference in multisensory perception. PLoS ONE 2(9): e943.

Mégevand, P., Molholm, S., Nayak, A., & Foxe, J. J. (2013). Recalibration of the multisensory temporal window of integration results from changing task demands. PLoS ONE 8(8): e71608.

Miller, J. (1982). Divided attention: evidence for coactivation with redundant signals. *Cognitive Psychology*, *14*, 247-279.

Vroomen, J., & Keetels, M. (2010). Perception of intersensory synchrony: A tutorial review. *Attention, Perception & Psychophysics*, *72,* 871-884.